SRTM, NED, and NLCD2001: Synergy of National Datasets for Biomass and Carbon Quantification in the United States

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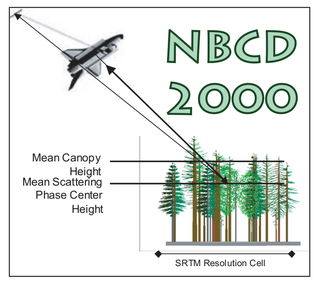
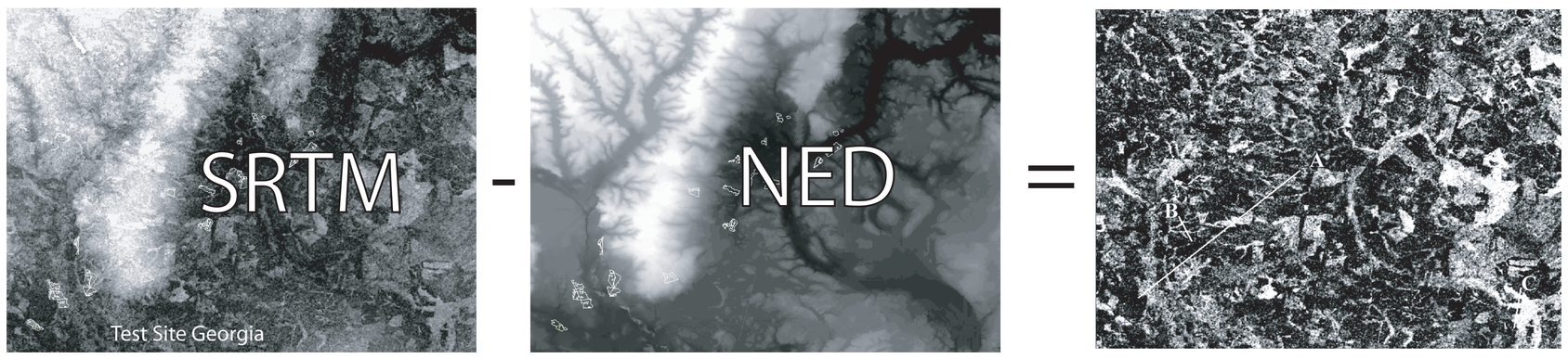


SUMMARY

A major goal of the North American Carbon Program (NACP) is to develop a quantitative scientific basis for regional to continental scale carbon accounting to reduce uncertainties about the carbon cycle component of the climate system. Given the highly complementary nature and quasi-synchronous data acquisition of the 2000 Shuttle Radar Topography Mission (SRTM) and the Landsat-based 2001 National Land Cover Database (NLCD), an exceptional opportunity exists for exploiting data synergies afforded by the fusion of these high-resolution data sources. Accurate area-based estimates of terrestrial biomass and carbon require biophysical measures that capture both horizontal and vertical vegetation structure. Whereas the thematic layers of the NLCD are suitable for characterizing horizontal structure (i.e., cover type, canopy density, etc.), SRTM provides information relating to the vertical structure, i.e., primarily height. Research from pilot study sites in Georgia, Michigan, and California has shown that SRTM height information, analyzed in conjunction with bald Earth elevation data from the National Elevation Dataset (NED), is highly correlated with vegetation canopy height. Currently, a project funded under the NASA "Carbon Cycle Science" program ("The National Biomass and Carbon Dataset 2000 – NBCD2000") is underway to generate a "millennium" high-resolution ecoregional database of circa-2000 vegetation canopy height, aboveground biomass, and carbon stocks for the conterminous U.S. which will provide an unprecedented baseline against which to compare data products from the next generation of advanced microwave and optical remote sensing platforms. In this project a collaboration with the Forest Inventory and Analysis (FIA) program of the USDA Forest Service will provide the reference data for model inversion of the SRTM/Landsat based parameters to generate the national biomass and carbon estimates.

PILOT STUDIES

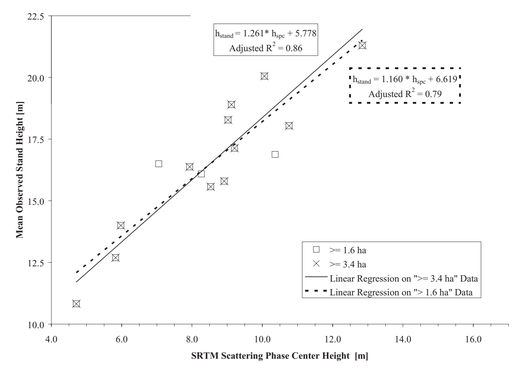


Research from pilot study sites in Georgia and California has shown that SRTM height information, analyzed in conjunction with bald Earth elevation data from the National Elevation Dataset (NED), is highly correlated with vegetation canopy height, yielding r2 values of 0.86 and 0.76 (rms errors of 1.2 and 4.4 m), respectively (Kellndorfer et al., 2004).

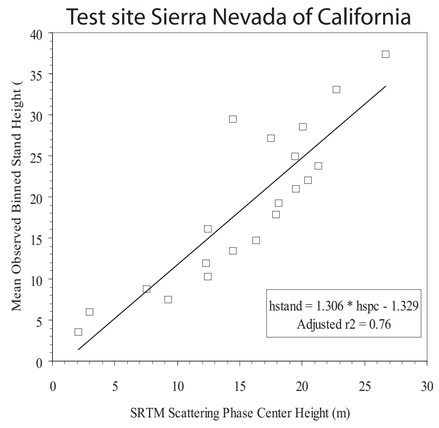
Inversion of Mean Canopy Height estimates from the SRTM-NED Difference is dependent on knowledge about vegetation type (e.g., coniferous, deciduous, mixed), canopy density, and ecoregion. Also, to drive the inversion models, reference measurements are necessary.

NLCD and FIA datasets can provide this additional knowledge.

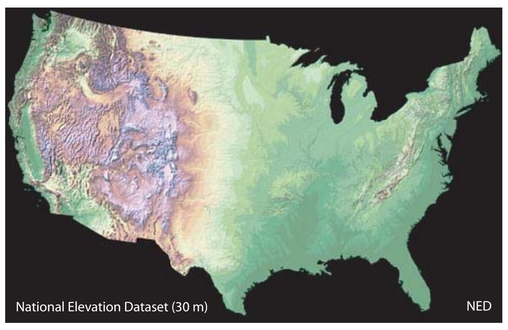
Test site Georgia



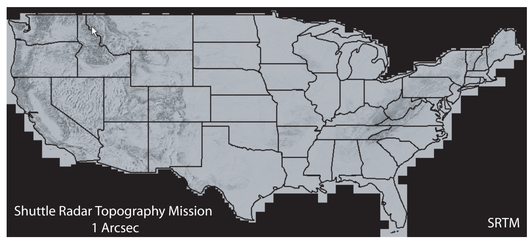
Test site Sierra Nevada of California

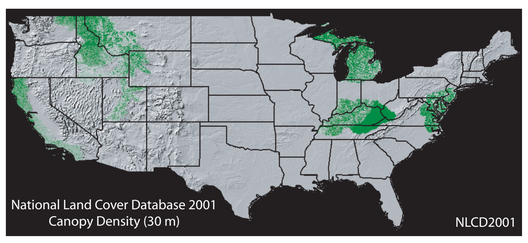


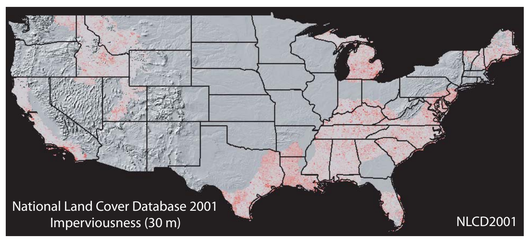
NATIONAL DATASETS OF THE U.S.

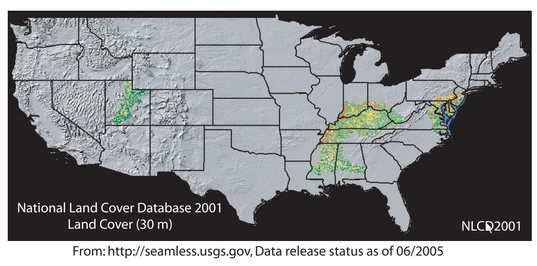


http://erg.usgs.gov/isb/pubs/factsheets/fs10602.html





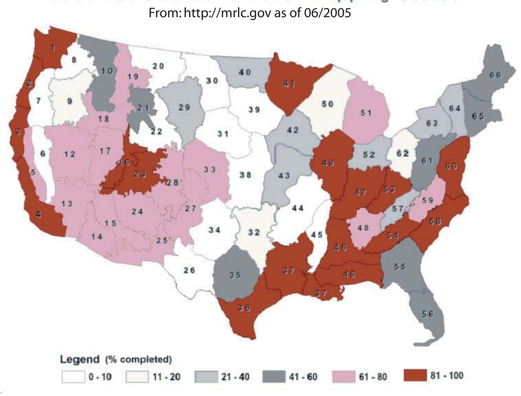




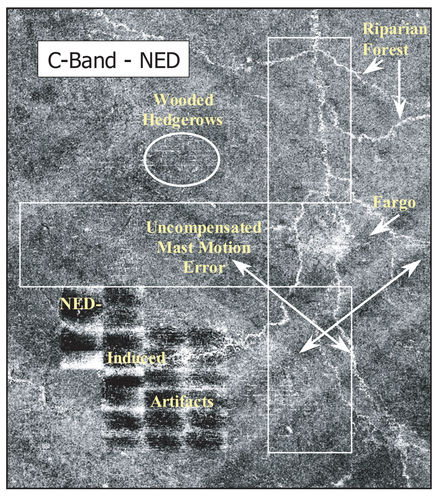
From: http://seamless.usgs.gov, Data release status as of 06/2005

2001 National Land Cover Mapping Status

From: http://mrlc.gov as of 06/2005



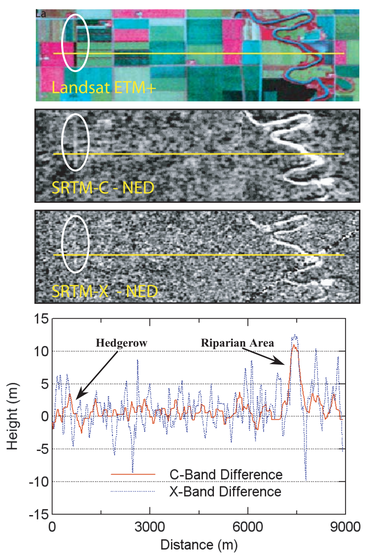
NOISE AND ERROR ISSUES

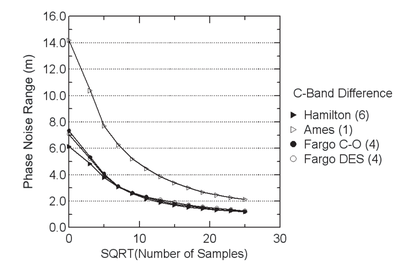


In order to fully understand the quality and accuracy of the SRTM data with respect to vegetation height characterization, we conducted several studies comparing SRTM and NED datasets in regions largely devoid of vegetation, where errors can be expected to be largest. Test regions were chosen where the number of data takes was one (Ames, Iowa), four (Fargo, North Dakota), and six (Hamilton, North Dakota).

The **figure to the left** shows the SRTM C-Band minus NED difference image of the Fargo region where several issues become obvious:
- Radar-typical fading-noise (salt and pepper) is present.
- Built-up and vegetated areas like hedgerows, riparian forest and the city of Fargo are standing out.
- A cross-wavepattern is visible which corresponds to the SRTM ground swath in the across-track direction.
- In the lower left portion artefacts can be seen which stem from an error in the NED dataset.

The **figure to the right** shows a 9 km SRTM-NED transect across fields bound by a hedgerow and riparian vegetation. The phase noise amplitude for X- and C-band can be identified.

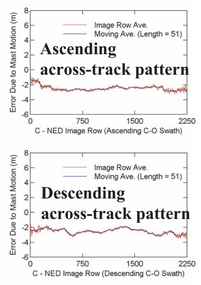


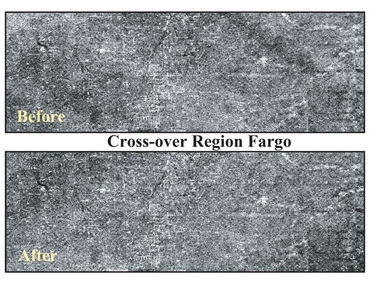


The **figure above** shows the dependency of phase noise on the number of averaged samples and the number of data takes for a given region.
Large agricultural fields within the test sites Ames (1 data take), Fargo (4) and Hamilton (6) were selected and the total range of elevation differences in the SRTM-NED data was determined (Y-axis). Subsequently the fields were block-averaged with fixed square windows and the range was redetermined (X-axis). As expected, more initial data takes for a given region significantly reduce the noise-range. A filter window of 5x5 samples reduces the noise range by ca. 50%.

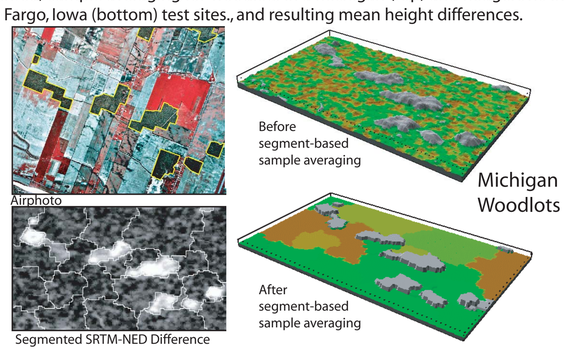
MITIGATION STRATEGIES

Mast motion induced errors can be addressed by deconvolving the datasets in descending and ascending portions to generate across-track (row) average functions which can subsequently be applied to reduce the error. Only samples devoid of vegetation should be used for the row averaging.

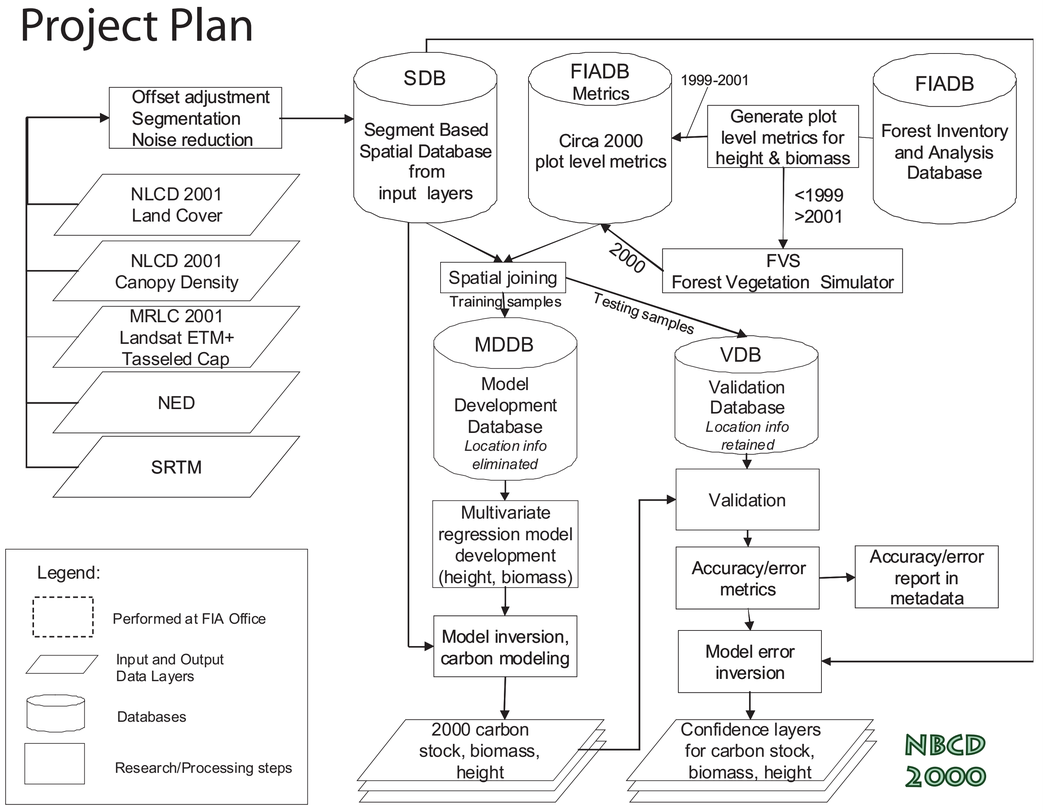




Phase noise is best mitigated through the averaging of samples. The amount of noise reduction is dependent on the number of data takes over a given region (see Figure in ERROR section). Below are examples of segment-based (object-oriented) sample averaging for woodlots in a Michigan (top) and hedgerows in the Fargo, Iowa (bottom) test sites., and resulting mean height differences.



NATIONAL BIOMASS AND CARBON DATASET 2000 Project Plan



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